Lower extremity arterial revascularization in obese patients

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Background: **Obesity and associated comorbidities are associated with a high rate of complications and technical difficulties after a number of surgical procedures. We studied the role of obesity in outcomes in lower extremity arterial revascularization.**

Methods: **We reviewed all lower extremity arterial revascularizations performed at our institution in 2000. Body mass index (BMI) greater than or equal to 30 kg/m^2 defined obesity. Perioperative outcomes, long-term survival, and graft patency were evaluated in obese and nonobese patients by using linear regression, the Fisher exact test, and Kaplan-Meier analysis.**

Results: **The study population consisted of 74 (26%) obese and 207 (74%) nonobese patients. Patient demographics of the obese and nonobese populations were similar. The mean BMI for obese patients was 35 ± 5 kg/m^2 and in nonobese patients was 25 ± 3 kg/m^2. The mean age of each group was 67 ± 10 years (BMI ≥30 kg/m^2) and 70 ± 13 years (BMI <30 kg/m^2). There were 45 (61%) obese men and 29 (39%) obese women. There were 128 (62%) nonobese men and 79 (38%) nonobese women. Diabetes was present in 76% of the obese and 70% of the nonobese patients. Perioperative myocardial infarction, 30-day mortality, and rate of reoperation within 30 days were not significantly different. Obese patients had higher increased postoperative wound infection rates (16% vs 7%; *P* = .04). Survival analysis showed 81% ± 5% and 85% ± 3% 1-year survival and 66% ± 6% and 62% ± 3% 3-year survival in obese and nonobese patients (*P* = .58), respectively. Kaplan-Meier estimates showed no effect of obesity on long-term graft patency, with 1-year graft patency rates of 82% ± 6% and 81% ± 4% in obese and nonobese patients, respectively (*P* = .79).**

Conclusions: **Obese patients have similar limb salvage rates, perioperative cardiac morbidity, long-term survival rates, and long-term graft patency but have increased perioperative wound infections. (J Vasc Surg 2007;46:738-42.)**

Obesity is an increasing problem in the United States.[1,2] Obesity is thought by many to increase the technical difficulty of surgical procedures and to have a major effect on the postoperative care of surgical patients. There has been limited evaluation of the effect of obesity on surgical outcomes.[3-6] Obese patients undergoing coronary arterial bypass grafting have been shown to have similar long-term survival and graft patency; however, they have increased perioperative wound morbidity when compared with nonobese patients.[3,4] The aim of our study was to evaluate the role of obesity on outcomes in lower extremity arterial revascularization.

Obesity is defined by using body mass index (BMI), calculated as weight (kilograms) divided by the square of height (meters). BMI is the most commonly used parameter to describe obesity. The National Institutes of Health has defined overweight as a BMI of 25 to 29.9 kg/m^2 and obesity as a BMI greater than 30 kg/m^2. Obesity is further divided into class I (BMI 30-34.9 kg/m^2), class II (BMI 35-39.9 kg/m^2), and class III, or morbid, obesity (BMI >40 kg/m^2).[7] For the purpose of this work, obesity and morbid obesity will be defined in accordance with the National Heart, Lung and Blood Institute classification.

Obesity is an epidemic in the United States population, whose trends have been studied through surveys conducted by the Centers for Disease Control and Prevention and the National Center for Health Statistics. These studies have shown that the overall prevalence of obesity has increased from 13.3% to 30.9% and that that of morbid obesity has increased from 2.9% to 4.7% since 1980.[2] Obesity is associated with significant comorbidities, including diabetes, hypertension, hypercholesterolemia, and an increased risk of death.[8-10] These comorbidities are assumed to have untoward affects on surgical outcomes in obese patients.

No study to date has been undertaken to evaluate the role of obesity on surgical outcomes in vascular surgery. Obesity poses technical difficulty in the performance of lower extremity revascularization and compounds many of the comorbidities of peripheral vascular disease. This prompted us to hypothesize that obese patients undergoing lower extremity arterial revascularization would have similar long-term survival and increased perioperative wound complication rates in comparison to nonobese patients.

METHODS

We retrospectively reviewed the medical records of patients who underwent lower extremity arterial revascular-

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ization at the Beth Israel Deaconess Medical Center from January 1, 2000, to December 31, 2000. Patient data were entered prospectively into a computerized vascular registry at the time of surgery. A board-certified vascular surgeon who was assisted by a resident performed all procedures. This study was approved by the Institutional Review Board at Beth Israel Deaconess Medical Center and included 294 adult patients who underwent 318 infrainguinal revascularization procedures. Data were incomplete for 13 patients, thus resulting in 281 patients for survival analysis.

Demographic data and perioperative risk factors evaluated for our study included age, sex, diabetes, smoking, coronary artery disease, congestive heart failure (CHF), angina, hypertension, arrhythmia, previous myocardial infarction, renal disease, creatinine >2.0 mg/dL, hemodialysis, operative time, and perioperative fluid balances. Technical factors studied included the indication for the procedure, level of distal anastomosis, and type of conduit used for bypass. Postoperative complications were prospectively entered into the registry by staff, fellows, residents, or support staff. Postoperative complications evaluated for this study included graft thrombosis, wound hematoma, lymphocele, wound infection, wound dehiscence, graft infection, CHF, renal failure, pneumonia, arrhythmia, sepsis, urinary tract infection, nerve injury, deep venous thrombosis, pulmonary embolus, 30-day reoperation, 30-day mortality, length of stay, and postoperative length of stay. Long-term outcomes studied were ipsilateral amputation rate, long-term survival, and long-term graft patency. Height, weight, and social security numbers were extracted by retrospective review of all medical records. Long-term survival data from the Social Security Mortality Database were gathered by using patient social security numbers.

BMI was calculated by dividing a patient's weight (kilograms) by the square of their height (meters). BMI categories were divided into nonobese (BMI <30 kg/m^2) and obese (BMI ≥ 30 kg/m^2) according to the National Heart, Lung and Blood Institute obesity classification. All demographic data are presented as percentage prevalence in the study populations. All mean data are presented as mean $\pm$ SD. Statistical analysis was performed by linear regression of BMI as a predictor against all demographic and outcome variables. The results of the linear regression were verified by using the Fisher exact test. Kaplan-Meier estimation of the survival distribution was performed for the obese and nonobese groups from the date of operation to the date of death. Long-term graft patency and amputation rates were evaluated by Kaplan-Meier analysis. The log-rank test for the equality of the survival distribution curves was used to evaluate for differences in long-term survival and graft patency. All statistical analyses were performed by a statistician using the statistical software R version 2.0.1 (public domain software free download). Results with a P value of $<.05$ were considered statistically significant.

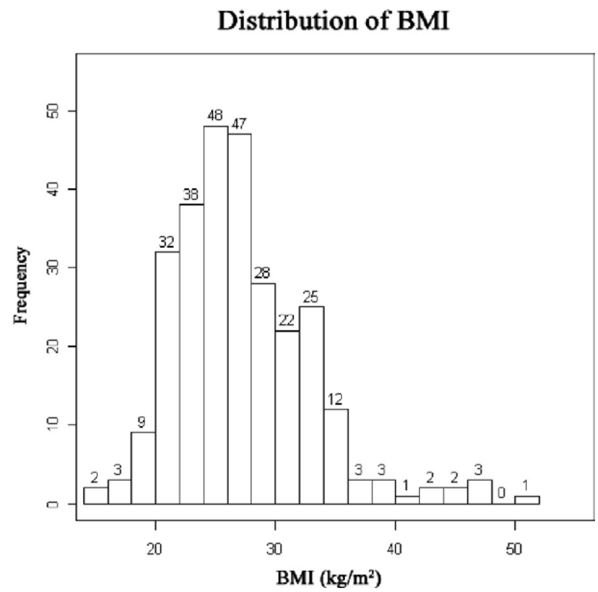

Fig 1. Distribution of body mass index *(BMI)*. This histogram shows the frequency of BMI found throughout the study population. The number over each bar is the number of patients with that BMI. The mean BMI is 27 ± 6 kg/m^2.

RESULTS

The study population consisted of 294 patients. Complete height, weight, and survival data were available for 281 (96%). There were 74 (25%) obese and 207 (75%) nonobese patients in the study population. The mean BMI in nonobese patients was 25 ± 3 kg/m^2, and the mean BMI for obese patients was 35 ± 5 kg/m^2. The BMI of the entire population showed a near-normal distribution (Fig 1), with a mean BMI of 27 ± 6 kg/m^2.

The obese patients were younger (67 ± 10 years) than nonobese patients (70 ± 13 years; $P = .03$). The obese population was composed of 62% men and 38% women. The nonobese population was similar, with 61% men and 39% women (not significant). Diabetes was prevalent in 70% of obese patients and 76% of nonobese patients (not significant). Overall the demographics of the two study groups were similar with respect to prevalence of diabetes, insulin use, smoking status, coronary artery disease, CHF, renal disease, creatinine greater than 2, and a history of renal transplantation (Table I). There was a trend toward decreased age, decreased hemodialysis use, and increased incidence of hypertension in the obese population (Table I).

Intraoperative characteristics of the study groups showed no significant differences. The indications for lower extremity arterial revascularization in obese patients were claudication (9%), limb ischemia (38%), rest pain (5%), infection (19%), gangrene (26%), and nonhealing ulcer (3%). The indications for surgery in nonobese patients were claudication (6%), limb ischemia (34%), rest pain (6%), infection (17%), gangrene (33%), and nonhealing ulcer (3%) (not significant). The overall case length was similar in

Table I. Demographics and comorbidities of the study population

Variable	P *value*	*Nonobese (BMI <30 kg/m²) (n = 207)*	*Obese (BMI ≥30 kg/m²) (n = 74)*
Age (y)	.03	70 ± 13	67 ± 10
Male	NS	128 (62%)	45 (61%)
Female	NS	79 (38%)	29 (39%)
Diabetes	NS	145 (70%)	56 (76%)
Insulin use	NS	95 (46%)	40 (54%)
Smoker	NS	34 (16%)	14 (19%)
Coronary disease	NS	112 (54%)	41 (55%)
Congestive heart failure	NS	45 (22%)	17 (23%)
Hypertension	.07	145 (70%)	60 (81%)
Renal disease	NS	51 (25%)	15 (20%)
Creatinine >2	NS	35 (17%)	7 (10%)
Renal transplant	NS	6 (3%)	3 (4%)
Hemodialysis	.09	23 (11%)	5 (6%)

BMI, Body mass index; *NS,* not significant.
Data are mean ± SD or n (%).

Table II. Technical outcomes

Variable	P *value*	*Nonobese (BMI <30 kg/m²) (n = 207)*	*Obese (BMI ≥30 kg/m²) (n = 74)*
Case length (d)	NS	210 ± 94	210 ± 87
Claudication	NS	12 (6%)	7 (9%)
Limb ischemia	NS	73 (35%)	28 (38%)
Rest pain	NS	12 (6%)	4 (5%)
Foot infection	NS	35 (17%)	14 (19%)
Gangrene	NS	69 (33%)	19 (26%)
Nonhealing ulcer	NS	6 (3%)	2 (3%)
Redo operation	NS	38 (18%)	12 (16%)
Saphenous vein	NS	144 (70%)	53 (72%)
Arm vein	NS	31 (15%)	10 (14%)
PTFE	NS	32 (15%)	4 (5%)
Bypass to popliteal	NS	67 (32%)	27 (37%)
Bypass below popliteal	NS	140 (68%)	27 (64%)

BMI, Body mass index; *NS,* not significant; *PTFE,* polytetrafluoroethylene.
Data are mean ± SD or n (%).

obese and nonobese patients (Table II). The technical aspects of the procedures performed showed a similar incidence of redo operations and level of distal anastomosis (Table II). The conduit used for revascularization was similar in both groups of patients (Table II). There were no differences in the rates of postoperative graft thrombosis, hemorrhage, wound hematoma, wound dehiscence, lymphocele, CHF, renal failure, graft infection, urinary tract infection, pneumonia, sepsis, deep venous thrombosis, pulmonary embolus, or nerve injury between groups (Table III). There was a trend toward increased postoperative arrhythmia (8% in the obese group vs 3% in the nonobese group; $P = .09$), total length of stay (11 ± 12 days vs 9 ± 7 days; $P = .06$), and postoperative length of stay (8 ± 11 day vs 6 ± 5 days; $P = .09$) in obese individuals (Table III). Postoperative wound infection rates (16% vs 7%; $P = .04$; odds ratio, 2.4; 95% confidence interval, 1.02-5.6) were significantly increased in obese patients (Table III).

Table III. Postoperative outcomes

Variable	P *value*	*Nonobese (BMI <30 kg/m²) (n = 207)*	*Obese (BMI ≥30 kg/m²) (n = 74)*
Postoperative length of stay (d)	.09	6 ± 5	8 ± 11
Length of stay (d)	.06	9 ± 7	11 ± 12
Graft thrombosis	NS	7 (3%)	3 (4%)
Hemorrhage	NS	3 (1%)	3 (4%)
Wound hematoma	NS	22 (11%)	5 (7%)
Wound infection	.04	15 (7%)	12 (16%)
Wound dehiscence	NS	4 (2%)	2 (3%
Lymphocele	NS	0	0
Congestive heart failure	NS	4 (2%)	2 (3%)
Renal failure	NS	3 (1%)	2 (3%)
Graft infection	NS	0	3 (4%)
Urinary infection	NS	1 (0.5%)	2 (3%)
Pneumonia	NS	1 (0.5%)	0
Sepsis	NS	0	0
Deep vein thrombosis	NS	0	0
Pulmonary embolus	NS	0	0
Nerve injury	NS	0	0
Arrhythmia	.09	6 (3%)	6 (8%)

BMI, Body mass index; *NS,* not significant.
Data are mean ± SD or n (%).

Table IV. Major complications

Variable	*Nonobese (BMI <30 kg/m²) (n = 207)*	*Obese (BMI ≥30 kg/m²) (n = 74)*
30-d myocardial infarction	5 (2%)	1 (1%)
30-d mortality	3 (1%)	0
30-d reoperation	16 (8%)	11 (15%)

BMI, Body mass index.
Data are n (%).

Major perioperative complications—including death, myocardial infarction, and 30-day reoperative rates—were similar between the two groups (Table IV). There was no difference in long-term survival for obese and nonobese individuals (Fig 2). One-year survival rates in obese and nonobese patients were 81% ± 5% and 85% ± 3%, respectively. Three-year survival rates were 66% ± 6% and 62% ± 3% in obese and nonobese individuals ($P = .6$). Long-term graft patency rates were similar in obese and nonobese individuals (Fig 3). One-year graft patency rates were 82% ± 6% and 81% ± 4%, and 3-year graft patency rates were 62% ± 9% and 64% ± 5% in obese and nonobese patients ($P = .8$). Ipsilateral amputation rates were 14% and 12% in obese and nonobese patients, respectively (not significant; Fig 4).

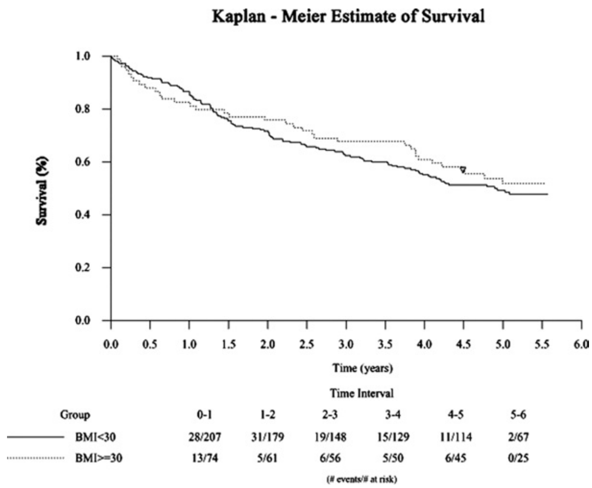

Fig 2. Kaplan-Meier curves plotting the fraction of the study population alive over time. The *solid line* represents survival in nonobese patients, and the *dashed line* represents the survival of obese patients. *Arrows* delineate where the standard deviation of the curve exceeds 10%. *BMI,* Body mass index.

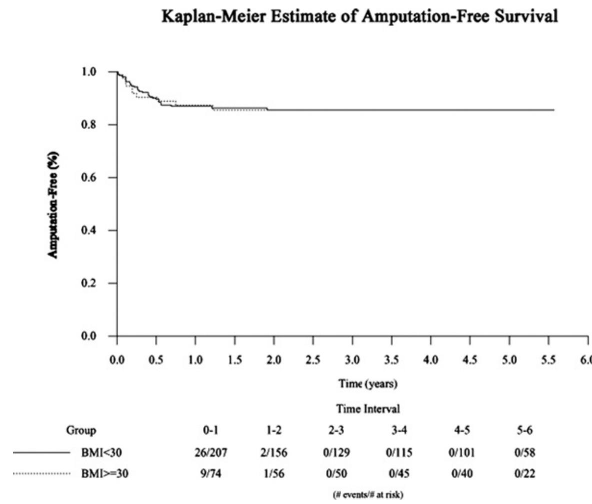

Fig 4. Amputation-free survival. Kaplan-Meier curves plotting the fraction of patients undergoing major amputation over time. The *solid line* represents freedom from amputation in the nonobese group, and the *dashed line* represents freedom from amputation in obese patients. *BMI,* Body mass index.

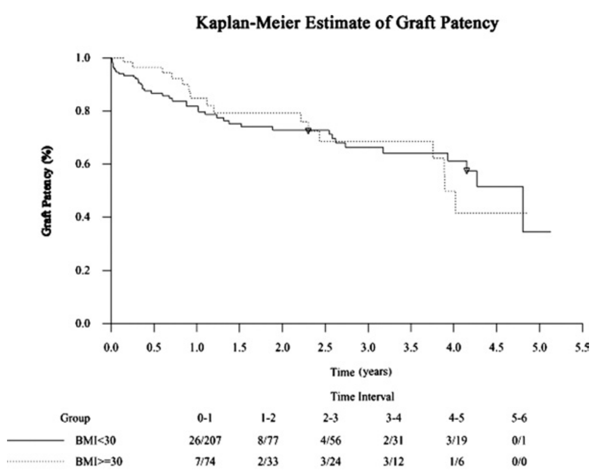

Fig 3. Kaplan-Meier curves plotting the fraction of graft patency over time. The *solid line* represents graft patency in the nonobese group, and the *dashed line* represents graft patency in obese patients. *Arrows* delineate where the standard deviation of the curve exceeds 10%. *BMI,* Body mass index.

DISCUSSION

Our study population had a normal distribution of BMI, and the mean of 27 ± 6 kg/m^2 was consistent with obesity trends in other studies. The actual percentage of obese patients (26%) in our population is reflective of the national average of 30.9%, but it is increased from the local and regional rates of 16.1% in Massachusetts and 16.9% in New England. Our center specializes in lower extremity arterial revascularization and the treatment of diabetic foot ulcers.[11] This increase in obesity relative to the local prevalence may be attributed to selection bias secondary to referral patterns from a major diabetes specialty hospital.

Our study, similar to others, used BMI as a measure of obesity. We divided our patient population into obese and nonobese according to the National Heart, Lung and Blood Institute guidelines for the definition of obesity (BMI >30 kg/m^2). Obesity subclass evaluation of our population resulted in 53 class I, 12 class II, and 9 class III obesity patients. Kaplan-Meier survival curves were generated for the obesity subclasses, and no survival differences were noted among the four groups (data not shown). We were not able to subclassify patients into class I, II, or III and meaningfully evaluate the outcomes given the high likelihood of type II error.

Obese patients were similar to nonobese patients with regard to demographic characteristics. Diabetes was equally prevalent in both groups, and both groups had similar rates of insulin use for blood sugar control. This similarity among groups is different from that reported by Birkmeyer et al[3] and Kim et al[4] and is likely attributable to the large diabetic population treated at our institution.

Wound infections were increased in obese patients with an odds ratio of 2.4 (95% confidence interval, 1.02-5.56). Wound infections were defined as any infection of the surgical incision which required an alteration in management, such as starting antibiotics, opening a wound, or debriding a wound. The increased infection rate in obese patients may be attributed to technical factors; however, the indications for revascularization, use of the saphenous vein as a conduit, and the complexity of bypasses was similar in both groups. Our center does not perform incision limiting or laparoscopic saphenous vein harvest. The use of incision-limiting techniques may decrease wound length and the extent of tissue dissection and may decrease wound infection rates. This argues for the study of minimal harvest techniques in obese patients. We did not evaluate the effectiveness of glycemic control in the perioperative setting, but all postoperative patients undergoing surgery at our institution are aggressively treated with insulin and oral hyperglycemic agents to maintain fingerstick blood glucose levels of 80 to 120 mg/dL. Increased insulin resistance and relative hyperglycemia may have accounted for the higher wound infection rates found in obese patients. Alterations in surgical technique and in postoperative management of obese patients may improve infection rates and warrant further study.

Long-term outcomes in obese patients were similar to those of nonobese patients undergoing lower extremity revascularization. Long-term survival was similar in both groups. Long-term graft patency rates were also similar in obese and nonobese patients. Limb salvage as assessed by the ipsilateral amputation rate was also similar in both groups. The results of our study echo similar studies performed on patients undergoing cardiac surgery. Kim et al[4] showed that obese patients had perioperative morbidity and mortality rates similar to those of nonobese patients and had similar 5-year survival curves. In that study, obese patients were also more prone to perioperative sternal infections.

The incidence of obesity is increasing in the United States; therefore, it will continue to be an increasing problem in surgery. Surgical outcomes in obese patients have been evaluated by a limited number of studies, including ours.[3-6] In our study, obese patients did not have increased perioperative mortality or myocardial infarction rates. We have shown that obese patients have long-term survival, graft patency, and limb salvage similar to those of nonobese individuals. Surgical outcomes in obese patients are most notable for an increased risk of wound infections. Obese patients undergoing lower extremity revascularization should be closely monitored for signs and symptoms of wound infection.

AUTHOR CONTRIBUTIONS

Conception and design: VIP, ADH, CH
Analysis and interpretation: VIP, ADH, MLS, CH, SD, DRC, FWL, FBP
Data collection: VIP, ADH, MLS, CH, DRC, FWL, FBP
Writing the article: VIP, ADH, MLS, CH, SD
Critical revision of the article: VIP, MLS, SD, DRC, FWL, FBP
Final approval of the article: VIP, ADH, FWL, FBP
Statistical analysis: VIP, CH, SD
Obtained funding: FWL, FBP
Overall responsibility: VIP

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